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independent observations can be made as will not interfere with the regular duties of the department. A few articles on comet places, features of *Jupiter* and the new star in *Auriga*, have been published during the past two years.

The meteorological equipment consists of maximum and minimum thermometers and rain-gauge. Records are kept throughout the year and monthly reports are sent to the New York Meteorological Bureau.

The first Director of the observatory was MARIA MITCHELL, of Nantucket, who took charge of the department at the opening of the college and retained the professorship for twenty-three years.

The final determination of the latitude of the observatory was secured by Miss MITCHELL in 1872 by a zenith telescope loaned by the U. S. Coast Survey, and that of longitude in 1877 by telegraphic connection with Harvard College Observatory.

ASTRONOMICAL PHOTOGRAPHS AT THE MID-WINTER FAIR.

BY ALLEN H. BABCOCK.

The LICK* Observatory exhibit at the World's Fair of 1893, in Chicago, was composed of about 100 specimens of the photographic work of various members of the staff of astronomers. It consisted chiefly of framed transparencies on glass and was placed in the exhibit of Santa Clara County in the California building. The location was an unfortunate one in some respects, for few who are interested in the subject would think of looking for an astronomical exhibit in the midst of a collection of fruits and cereals. The photographs were moved to San Francisco at the close of the World's Fair, are now on exhibition in the Santa Clara County building at the Midwinter Fair, and later will be presented to the Chicago Academy of Sciences.

The Regents were determined that the University should be properly represented at the Midwinter Fair and to that end made an appropriation of \$5000 for a University exhibit. As a whole, the exhibit of the University of California is very dignified and appropriate. It occupies the whole of the north gallery of the

Liberal Arts building, and consists of exhibits which are intended to illustrate the work of its various departments—those of arts, pure science, of engineering, mines, mechanics, metallurgy, agriculture, etc.,—which now contain some 1400 students, directed by some 180 professors and instructors. Two hundred dollars was assigned to the LICK Observatory as its share of the appropriation. This sum was scarcely sufficient to pay for the negative plates used, and would have been entirely inadequate to make a proper exhibit at San Francisco, if it had not been that the Observatory had begun its preparation several months before and had already made considerable progress when the Regents decided to make a University display. The result is worthy the attention of all those interested in the science, in one of the most important applications of photography, and in the great Observatory itself. The Observatory exhibit at San Francisco consists of some 250 transparencies on glass, usually 8 x 10 inches in size, which are copied from the original negatives preserved at Mount Hamilton. They are hung along and over the rail of the gallery and are readily examined by those who are passing. Each photograph bears a label which gives a short account of the subject of the picture, the name of the photograph, etc.

Modern study of the Sun is illustrated by the eclipse pictures of January, 1889, December, 1889 and April, 1893, especially by the incomparable negatives of the latter eclipse made by Professor SCHAEBERLE in Chile. It will require months of study to develop the mine of information contained in them. The results so far obtained tend to substantiate the mechanical theory of the solar corona, as has been announced already. A peculiarly interesting feature of these negatives is that they show upon them the figure of a large comet which was passing close to the Sun at the moment of the eclipse. When Professor SCHAEBERLE first announced this fact, it was evidently regarded with doubt by the other eclipse observers, who had also made negatives of the same eclipse. In the course of time copies of the British negatives, taken in Brazil and in Africa, came to Mount Hamilton, and Professor SCHAEBERLE at once found on them the eclipse comet, thus proving, at the same time, the fact of the existence of the comet and his own skill as a keen observer. This is the second comet which has been photographed at an eclipse, though it is far fainter than the comet of 1875, which was visible to the naked eye.

Trials have shown that the atmospheric conditions at Mount Hamilton are not favorable to regular observations in the daytime, on account of the disturbed conditions of the air at the top of the mountain; but the admirable negatives of the Sun by Mr. C. D. PERRINE, prove conclusively that by persistent watching for favorable moments, as good results can be obtained in this as in other lines of work. The enlargements of these negatives by Mr. A. L. COLTON afford an opportunity for the study of the details of Sun-spots. The partial eclipse of October, 1893, was also photographed by Mr. PERRINE, but the results are somewhat unsatisfactory on account of the cloudy weather prevailing almost the entire day.

The photographs of *Jupiter* taken, 5 and 8 times enlarged, with the great telescope, are extremely fine. They are the work of Professor HOLDEN. One of these has been again enlarged in the camera by Mr. COLTON to 30 diameters. The series of *Jupiter* negatives constitute a very satisfactory history of the planet since they were begun in 1890.

Up to the present time it has been impossible to secure good photographs of *Mars*, on account of its low altitude. The planet is so small and the polar caps so bright, that if sufficient length of exposure is given to bring out the details on the disc, the halation effects at the poles, etc., produce a distorted image. It is hoped that good negatives will be secured at the coming opposition when the altitude of the planet will be considerable. A set of photographs of the elaborate series of drawings of *Mars* made at the opposition of 1892 with the 36-inch telescope are especially noteworthy. It is interesting to compare the LICK Observatory drawings, which are full of detail, with the drawings made at the Arequipa Observatory at the same opposition.

As might be expected from his record as a comet-seeker, Professor BARNARD has sent some beautiful specimens of his work on comets, nebulae and the Milky Way. These last named are extremely beautiful and possess at least one quality seldom met with in celestial photography. Professor BARNARD has succeeded in producing photographic images that present nebulous cloud forms similar to those presented to the eye by the originals in the sky. In the case of the comet negatives, their value arises from diametrically opposite reasons. The human eye is so imperfect a piece of apparatus, that it cannot record the delicacies of comet structure even when aided by the most perfect telescope

in existence. It cannot pay attention long enough. The result is that a photographic plate, if exposed for a sufficient length of time, will present an appearance quite different from that which the comet presents to the eye when viewed with the same instrument which was used in taking the photograph. The negatives of SWIFT's comet of 1892 are particularly worthy of mention in this regard. They show the most remarkable changes in structure, especially of the tail,—changes which took place with such unusual rapidity, that the accuracy of the observations might be called in question, were it not for the permanent photographic records. Many of the changes in details, in fact the existence of the details, might never have been discovered except by aid of the photographic plate. The photographs of Comet *B*, 1893, by Professor HUSSEY, and of BROOKS' and GALE's comets by Professor BARNARD, disclose similar features. Professor BARNARD's discovery of a comet on one of his Milky Way plates of October 12, 1892, stands unique as the first discovery of a comet by purely photographic means. The object is so minute, and the plate so completely covered by star images, that it required a skilled and critical observer to detect anything unusual in the appearance of the plate. His negatives of the *Andromeda*, WOLF and SWIFT nebulae, are especially good, those of the trails of the *Hyades*, *Orion* and the circumpolar stars are interesting as illustrating the apparent motion of the stars, while those of the various instruments of the LICK Observatory, interiors of the buildings, snow scenes and landscapes in the neighborhood of the Observatory, add to his reputation as a skilled photographer.

Any account of the nebula transparencies would be incomplete without mention of the splendid specimens secured by Professor SCHAEBERLE on his eclipse expedition to Chile in 1893. All of these nebulae and star clusters are invisible at this latitude. In addition to the above, he has sent several photographs of *Nova Aurigæ*, which are part of a series giving a complete account of its changes of photographic magnitude.

Recent developments in stellar spectroscopic work are illustrated by the admirable photographs of Professor CAMPBELL. All these photographs have been taken with a visual spectroscope attached to the 36-inch equatorial and temporarily adjusted for photography, a combination not the most advantageous for this class of work. Mr. D. O. MILLS of New York has given a new photographic spectroscope, which has just been completed

by Mr. BRASHEAR, after Professor CAMPBELL's designs. With this new instrument it will be comparatively easy to carry out the spectroscopic work of the Observatory, which has so far been performed under serious disadvantages. Professor CAMPBELL's photographs of the spectra of *Nova Aurigæ* and of the later comets, form an instructive collection. His landscapes, notably one of the big fires of 1891 near Mount Hamilton, views near and around the Observatory and the University of California, are beautiful specimens of the photographic art.

The large collection of Moon photographs is composed of originals made with the 36-inch telescope by Professor HOLDEN, and of enlargements of them made by Mr. COLTON, Baron VON ROTHSCHILD, Mr. NIELSEN and by Dr. SPITALER and Professor WEINEK. These enlargements show in minute detail the principal lunar formations on a large scale, and are to form parts of a complete atlas of the whole Moon. The later prints by Professor WEINEK are enlarged 24 times, or to a scale of 10 feet to the Moon's diameter. It is proposed to make a photographic map of the entire visible surface of the Moon on that scale, also one on the scale of 3 feet to the Moon's diameter, in each of which every crater will be shown under at least two different illuminations,—under morning and evening Sun, for example.

The superb views from the top of Mount Hamilton are well illustrated by a panorama by Mr. COLTON. Beside these and his photographs of several of the principal constellations, Mr. COLTON has secured some exceptionally fine photographs of the Observatory and surroundings under varying conditions of weather. The views of cloud forms, fog and snow effects are especially attractive to those who live in lower altitudes. Some of Mr. PERRINE'S snow pictures, especially those showing the curious deposit on the trees, of frost formed directly from the clouds blowing over the surface of the mountain, remind one of the winter scenes around Niagara Falls.

The exhibit taken as a whole is one of which all may be proud, those who provided the material, as well as all friends of the Observatory and University. That it has been appreciated is shown plainly by the crowds passing before it day after day. If it awakens in only a few of those who pass by an interest in the science of astronomy, or even a desire to add one new fact to their knowledge, it will have done a good work, not to mention

the pleasure and information it has given to those who are enthusiasts already and who have been privileged to study it.

The Harvard College Observatory (Professor E. C. PICKERING, Director), has sent to the Fair an interesting and important exhibit of photographs and engravings which illustrate its long and honorable history, and which show the progress of the great works now being carried on in both hemispheres in photography, photometry and in spectroscopy. The exhibit is well displayed in a large room adjacent to the space occupied by the LICK Observatory.

The Physical Laboratory of the JOHNS HOPKINS University also occupies an adjacent space with an exhibit of the magnificent spectrum maps made by Professor ROWLAND. One of ROWLAND'S concave diffraction gratings forms a part of the exhibit and is so displayed as to project the spectrum of the Sun by day and of the electric arc lights by night.

(FIFTEENTH) AWARD OF THE DONOHUE COMET-MEDAL.

The Comet Medal of the Astronomical Society of the Pacific has been awarded to W. F. DENNING, Esq., F. R. A. S., of Bristol, England, for his discovery of an unexpected comet on March 26, 1894.

The Committee on the Comet-Medal,

EDWARD S. HOLDEN,
J. M. SCHAEFERLE,
CHAS. BURCKHALTER.

May 26, 1894.

ON THE FORMS OF THE DISKS OF *JUPITER'S*
SATELLITES.*

The contradictory results obtained by different observers of *Jupiter's* satellites seem to indicate that with our present instrumental means it may be impossible to decide definitely the exact form of celestial bodies presenting very small disks. The evidence

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